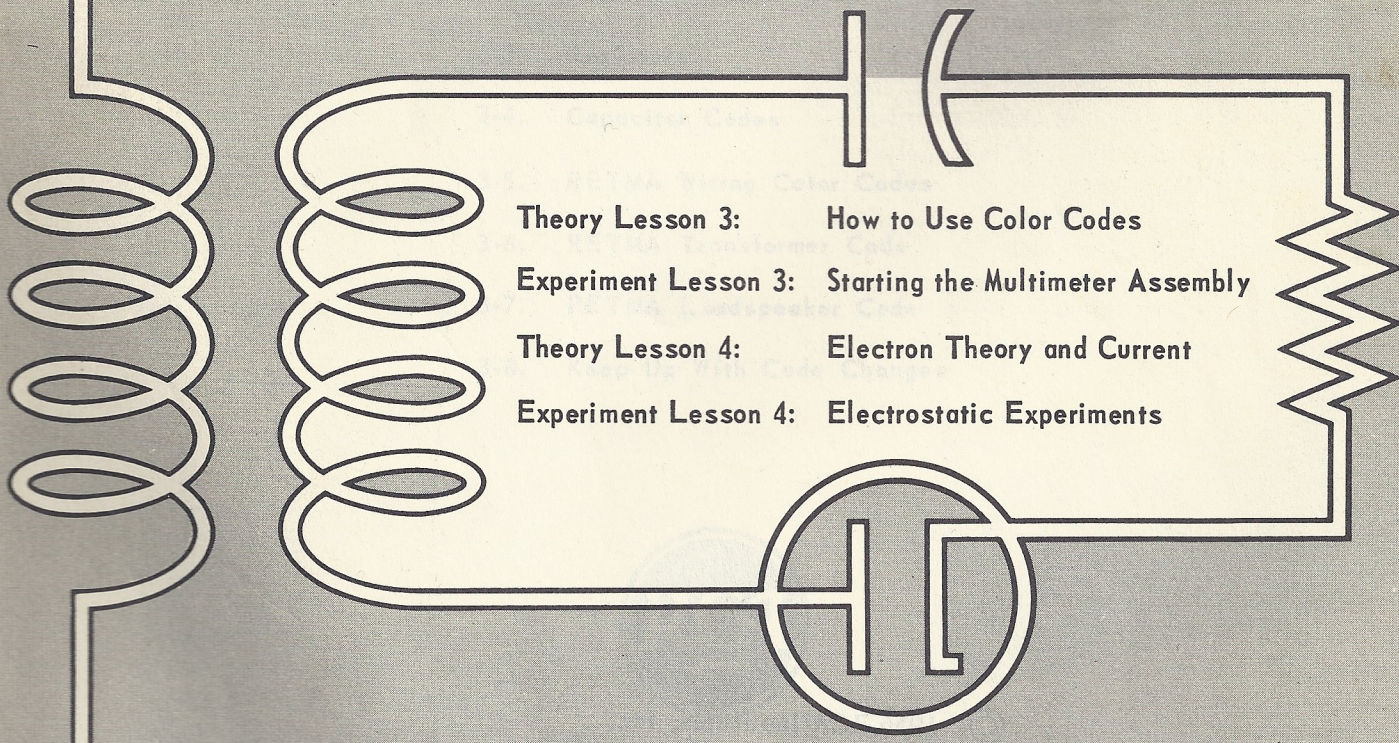


ELECTRONIC FUNDAMENTALS



Theory Lesson 3: How to Use Color Codes
Experiment Lesson 3: Starting the Multimeter Assembly
Theory Lesson 4: Electron Theory and Current
Experiment Lesson 4: Electrostatic Experiments

RCA INSTITUTES, INC.

A SERVICE OF RADIO CORPORATION OF AMERICA

New York,

N. Y.



ELECTRONIC FUNDAMENTALS

THEORY LESSON 3

HOW TO USE COLOR CODES

- 3-1. Color Code Adopted
- 3-2. The Basic Color Code
- 3-3. Resistors
- 3-4. Capacitor Codes
- 3-5. RETMA Wiring Color Codes
- 3-6. RETMA Transformer Code
- 3-7. RETMA Loudspeaker Code
- 3-8. Keep Up With Code Changes



RCA INSTITUTES, INC.

A SERVICE OF RADIO CORPORATION OF AMERICA

HOME STUDY SCHOOL

350 West 4th Street, New York 14, N. Y.

Theory Lesson 3

INTRODUCTION

In the early 1920's, when radio broadcasting was very new, most radio receivers were made at home. The parts that went into them were very difficult to obtain. In fact, many of them were hand-made by boys and young men who were anxious to be among the first to own one of the new-fangled wireless sets. In assembling one of these early radios, many hours were spent winding coils on large wooden coil forms or empty oatmeal boxes. As a result, some of the coils were actually larger than some radio receivers are today (see Fig. 3-1). However, some of the parts, such as resistors and capacitors, had to be bought, and there were very few stores that sold them.

In some cases, the parts were marked with the value of the resistance or capacity. In other cases, you just took the salesman's word that he was giving you the value that you had asked for. For example, the capacity of a mica capacitor might be painted or stamped on it, or it might be pressed into the bakelite case, if it had one. When it came to resistors, sometimes the only way you could

tell the value of a resistor was by the value marked on the box that it came out of. If someone had returned a resistor to the wrong box, the resistor you bought might be entirely different in value than the resistor you wanted.

In the few factories where radio receivers were made in those days, the problem of knowing one part from another was even greater than it was for the individual set builder. In a parts stock room, one box might contain several hundred resistors of a certain value. The box next to it might contain resistors of an entirely different value. If they got mixed up, as they sometimes did, there was no way in which anyone could tell the difference, except by measuring them with meters, which at that time were very scarce. One manufacturer developed a special color code for making resistors used in his radios, but only that manufacturer and some of his employees knew the code. The result was that when a radio serviceman fixed a radio with these coded resistors in it, he could not read resistor values unless he was an employee of the manufacturer.

3-1. COLOR CODE ADOPTED

However, most resistors and capacitors were not coded. With one resistor looking very much like the next one, you can well understand how mistakes were made and time was lost in making the necessary changes when wrong resistors were wired into new radio receivers. So, after some time, certain manufacturers started an organization that they called the Radio Manufacturers Association, which is now known as the Radio-Electronics-Television Manufacturers Association (RETMA, for short). Among other things, they decided to set up ways to prevent such mistakes. They de-

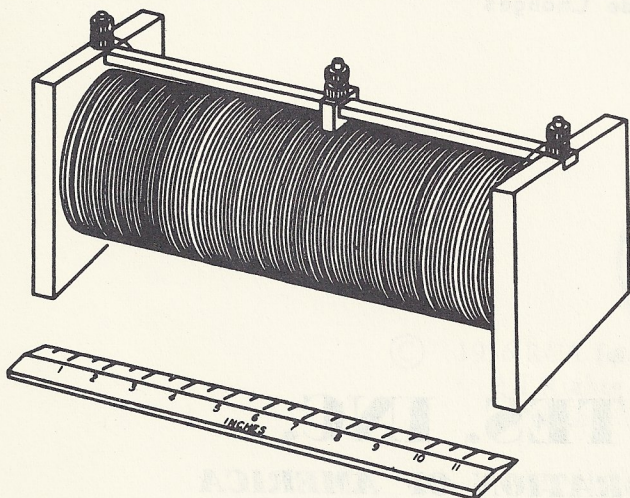


Fig. 3-1

vised a color code for marking resistors and capacitors for easy identification, and mistakes became less frequent.

Today most carbon composition and ceramic-cased wire-wound resistors are color coded. In addition, some paper-dielectric capacitors, all mica-dielectric capacitors, and most audio-frequency and radio-frequency transformers are color coded. Even the wiring of some radios and other electronic devices is marked with a color code, so that the various circuits may be identified by the color of wire used. More and more, it is important that people in radio be familiar with these codes. In any working day, a serviceman uses his knowledge of color codes many times. For example, color codes help him to identify resistors and capacitors in his stock, to identify the leads of the different types of transformers that are in a receiver, and to locate parts and trace circuits. When making his purchases of replacement resistors and capacitors, he may save a repeat trip to the distributor by checking the value of the parts he buys before he leaves the salesroom.

While some servicemen sometimes make use of color-code cards, color-code wheels, and other similar devices to identify the values of resistors and capacitors, this method is a time waster. Each time a repairman finds a resistor or capacitor that he wants to identify, he has to refer to his card or color-code device to find the value of the part. A serviceman who relies on such aids is lost when he forgets to take his color-code card on service calls away from his shop. On the other hand, if he *knows* the color codes, he just can't leave them behind, so he always has the answers when he needs them. The man who really knows his color code works much more surely without constant reference to cards, so he makes a good impression on his customers. Customers realize that such a man knows what he is doing. The man who often refers to color cards and other notes gives the customer the impression that he is weak in his radio knowledge. For these and other reasons, it is very important that you learn the basic color code and how it is applied to coded parts.

In this lesson, most of the normally used color codes are included. These codes are brought together in this one lesson so that they will be available to you for reference, now and in the future. For that reason, it is suggested that, when you are through with this lesson and have learned the basic code and how it is used, you bind this lesson with your Service Practices booklets. Then you will have the color codes always available for ready reference.

3-2. THE BASIC COLOR CODE

The basic color code consists of ten colors. Each of these colors, as shown in Table A, represents a digit from 0 through 9. Before you can learn any code, it is necessary that you learn what digit each of these colors stands for. The quickest and easiest way to learn this basic color series is by rote—which means by memorizing the colors in order. By repeating them over and over, as perhaps you learned your alphabet, you will find that you should know them in 15 to 30 minutes. When you can repeat them—black, brown, red, orange, yellow, green, blue, violet, gray, white, in that order, without hesitation—read on and see how these colors are applied to the first color code, which is the color code for identifying resistors.

TABLE A - BASIC COLOR CODE

Color	Digit
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Violet	7
Gray	8
White	9

3-3. RESISTORS

Just as it is possible to drive an automobile, operate an adding machine, or use an

electric shaver without knowing the theory behind them, so it is possible to use resistors without knowing what they do. You will learn about resistors in the next few lessons, but, for the time being, we are going to talk about resistors just as radio parts without going into the theory behind them.

In Service Practices 1, How To Identify Radio Parts, you saw pictures of typical resistors. In radio and TV receivers, carbon resistors are used most often and they look like those shown in Fig. 3-2. Figure 3-2a shows an *axial-lead resistor* (one where the leads are in line with the axis of the resistor). Most of the fixed carbon composition resistors now being made are of this type. Figure 3-2b shows a resistor with *radial leads* (each lead radiates out from the end like a spoke of a wheel does from its hub). Although practically no resistors of this type are being made any more, many millions of receivers contain them. No doubt you will find many of them in your service work, so it is necessary for you to know how to identify them when you see them. For that reason, they have been included in this lesson.

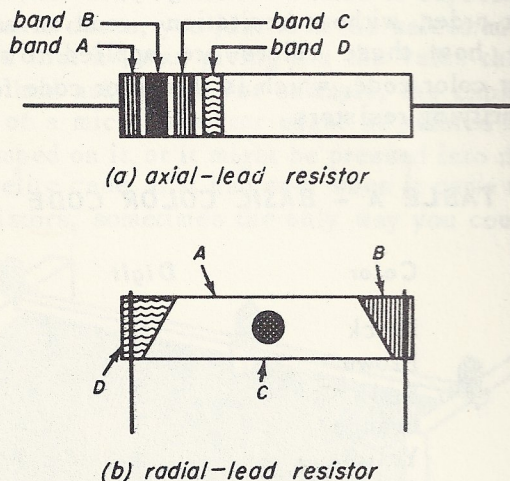


Fig. 3-2

If you will carefully examine the illustration of the axial-lead resistor, you will see that there are four color-bands used to identify the resistor value. The first of these, marked Band A, stands for the first *significant figure*. Just what is a significant figure? You will meet this term many times in this

course, so let's stop a moment and see what it means.

Significant Figures. Significant figures are those that are known to be correct by direct measurement or meaningful calculation. For example, suppose a motorist does 3 miles in 7 minutes. His rate of speed is 3 miles divided by $7/60$ hours. If the long division is carried on and on, an answer of 25.7142 miles per hour can be obtained. But the last four digits of the answer are not justified — the original measurements are not this accurate. The result should contain only two significant figures, 26 miles per hour. The answer is *rounded off* to the next higher number when the next digit is 5 or more; the next is dropped if it is 4 or less. Thus, if our answer had been 25.3, it would be rounded off to 25 miles per hour.

The resistor color code is capable of giving the values of resistors correct to 2 significant figures. Thus, a resistor whose actual value might be 27,374 ohms is labeled by the color code as a 27,000-ohm resistor. In this case, the three zeroes are not significant figures. They certainly are important, because they tell the order of size of the resistor. It is 27,000 ohms, not 270 ohms or 270,000 ohms. But the zeroes do not really tell the true value of the digit that should be in the third, fourth, and fifth position of the number, and in technical language, are not significant figures. If the resistor were actually 27,000 ohms, it would be written 27,000.0 ohms to show this fact.

A resistor value that is given as 1,000 ohms contains two significant figures, because this number tells us that it is closer to 1,000 than it is to 990 or 1,100 ohms. However, the last two zeroes in this case are not significant, because we have no way of knowing if the true value is really 1,000 ohms, or 1,012 ohms, or 998 ohms. The last two zeroes only fix the order of size of the resistor.

Resistor Color Code. We have already pointed out that band A stands for the first significant figure. Band B stands for the second significant figure. Band C is called the *multiplier*; it stands for the number of tens by which you must multiply the two sig-

nificant figures you read on the first two bands. Stated another way, the multiplier band tells you how many zeros you must add to the significant figure to get the correct value. Band *D*, the fourth band, stands for the *tolerance* of the resistor. By tolerance, we mean the amount that a part may vary from the rated value that is indicated on the first three bands.

It is necessary to provide a tolerance indication because it is very difficult to make carbon composition resistors of an exact value. Usually the value of a resistor, as it is marked on the first three bands, is a compromise value between the highest and the lowest possible values that the resistor might have. For example, a resistor might be marked as rated for 1,000 ohms. Reading the tolerance band, we learn that the actual value of the resistor may be as high as 1,200 ohms or as low as 800 ohms. Because tolerance is usually expressed as a percent of the rated value, we speak of this resistor as having a tolerance of $\pm 20\%$ (plus or minus twenty percent). In this way, we are saying that the resistor will have a value that is somewhere between the rated value plus 20% and the rated value minus 20%. Resistors for use in radio and TV receivers are classified in three *tolerance* groups: those that vary as much as 20% above or below the rated value, those that vary as much as 10% above or below the

rated value, and those that vary as much as 5% above or below the rated value. Very few resistors are now made with a 20% tolerance, although they may be found in many older radio receivers. Resistors having a tolerance of less than 5% have their value in ohms and tolerance in percent imprinted on the body. These are called precision resistors. To indicate tolerance, we use two additional colors: gold and silver. If the tolerance of a resistor is $\pm 5\%$, Band *D* is gold. If the tolerance is $\pm 10\%$, Band *D* is silver. If the tolerance is $\pm 20\%$, there isn't any fourth band. Thus, resistors with only three color bands have a tolerance of $\pm 20\%$. When reading resistors without tolerance bands, remember to start with the band nearest the end of the body.

Examine Table B. It shows what each color on the four color bands found on carbon composition resistors and ceramic-cased wirewound resistors stands for. For example, suppose a resistor has four color bands as follows: brown, black, brown, silver, as in Fig. 3-3. Looking at the chart, you will find that the brown of Band *A* stands for the digit 1, and the black of Band *B* stands for zero (0). The first two figures, then, are 1 and 0. The brown of Band *C* stands for a multiplier of 10. You learned in school that to multiply a number by 10 you just add a zero to the

TABLE B - RETMA CARBON COMPOSITION RESISTOR CODE
Also Military Standards of Defense Department.

Color	Band A—First Significant Figure	Band B—Second Significant Figure	Band C - Multiplier		Band D - Tolerance
			Multiplier	Number of Zeros Added	
Black	0	0	x1	Add no zeros	
Brown	1	1	x10	Add 0	
Red	2	2	x100	Add 00	
Orange	3	3	x1,000	Add 000	
Yellow	4	4	x10,000	Add 0000	
Green	5	5	x100,000	Add 00000	
Blue	6	6	x1,000,000	Add 000000	
Violet	7	7	x10,000,000	Add 0000000	
Gray	8	8	x100,000,000	Add 00000000	
White	9	9	x1,000,000,000	Add 000000000	
Gold			x 0.1		$\pm 5\%$
Silver			x 0.01		$\pm 10\%$
No Color					$\pm 20\%$

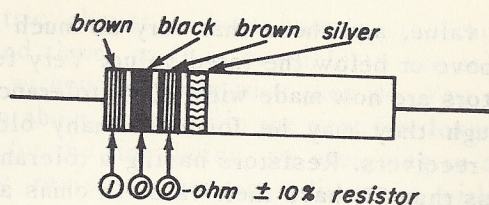
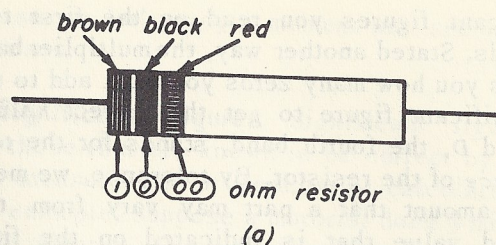


Fig. 3-3

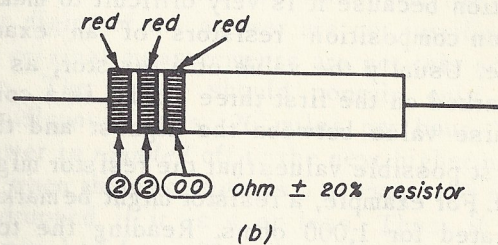
number. So in this case, we take the two significant figures we already have, 10, and multiply them by the multiplier, 10. We do this by adding zero to the two significant figures and we get 100. The unit of resistance value is the *ohm*, so the value of the resistor is 100 ohms. Band *D* is silver, which means that the tolerance is plus or minus 10%. Therefore, the color code identifies a resistor of 100 ohms with a tolerance of plus or minus 10%; therefore the resistance has a value between 100 plus 10% or 110, or 100 minus 10% or 90.

Before we go on to another resistance value, let's take a moment and examine the column under Band C — Multiplier. You have noted that black stands for 0 as a significant figure in bands A and B, and that brown stands for 1, red stands for 2, and so forth.

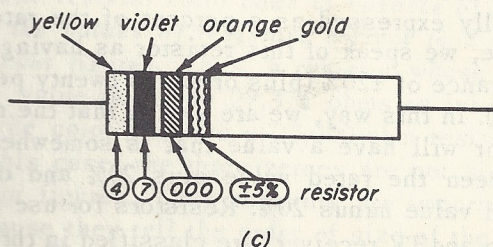
The same idea is carried out in the third band, because the multiplier *black* shows that we multiply the first two figures by 1. So, if a resistor is coded brown, black, gold, the first digit would be 1, the second digit would be zero, and because the third band is black, we would multiply the first two digits by 1 (no zeros are added). As a result, we would find the resistor value to be 10 ohms plus or minus 5%. A thousand-ohm resistor on the other hand, as shown in Fig. 3-4a, is coded brown, black, red, and whatever tolerance band is suitable. The red multiplier shows that we multiply the first two figures by 100, which just means adding two zeros to the first two digits. An orange multiplier means adding three zeros; yellow, four zeros; green, five zeros; and so on. A resistor coded red, red, and red, as in Fig. 3-4b, is decoded as 2,200 ohms and, because there is no tolerance band, it has a tolerance of plus or minus 20%. A resistor of 47,000 ohms plus or minus 5% would have a yellow Band A, violet Band B, orange Band C, and a gold Band D, as shown in Fig. 3-4c.



(a)



(b)



(c)

Fig. 3-4

Up to now we have discussed only values of resistance of 10 ohms or over. What happens when the color code is applied to lower resistor values? Let's see. If the resistance is one ohm, we cannot code it brown, black, black, because that is the code for 10 ohms (black as a significant figure is zero). To encode (to put into code) a resistor of one ohm, the first significant figure is one (brown) and the second significant figure is zero (black) as shown in Fig. 3-5a. Gold is used as a multiplier in the third band. On the chart, at the bottom of the Band C — Multiplier column, you will find that gold is a decimal multiplier equal to 0.1 (1/10) and that silver is a decimal multiplier equal to 0.01 (1/100). When gold appears in the *third* band, it does not indicate tolerance, but that the figure obtained from the first two bands is to be multiplied by 0.1. Now, on a resistor of 0.1 ohm, the first color band would be brown, the second one would be black, and

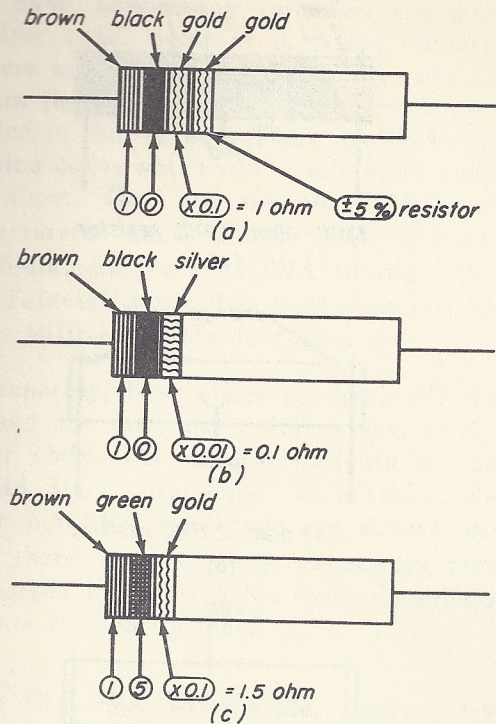


Fig. 3-5

the multiplier band would be silver, as in Fig. 3-5b. This would be decoded by multiplying 10 by 0.01 and getting a resistor value of 0.1 ohm. In much the same way a resistor coded brown, green, and gold would be decoded: 1, 5, and a multiplier of 0.1, as in Fig. 3-5c. So multiplying 15 by 0.1, the value of resistance is found to be 1.5 ohms.

Wirewound Resistor Code. The same basic code that is used on carbon composition resistors is also used to identify low power (2 watts or less) wirewound resistors. For that reason, it is not possible to tell the difference between these resistors by looking at color alone. Yet, it is necessary to be able to tell a carbon composition resistor from a wirewound resistor, because sometimes only one or the other can be used in a circuit. It is done in this manner: Carbon composition resistor color bands are of equal width; Band A, in wirewound resistors, as shown in Fig. 3-6, is *twice the width* of the other bands. So whenever you see that the first band of a resistor is wider than the other bands, you will know that the resistor is wirewound.

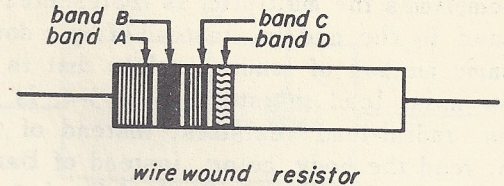


Fig. 3-6

Uninsulated resistors (excepting radial lead resistors) have black bodies. Insulated resistors commonly have tan bodies. Both types have colored bands to indicate their values.

Radial-Lead Resistor Code. Up to this point little mention has been made of the radial-lead resistor, which was shown in Fig. 3-2b. Changes in manufacturing methods have made radial-lead resistors out of date, and they are no longer made by leading manufacturers. However, there are so many of them in radios all over the country that it is necessary for you to know how the color code applies to them. Instead of being arranged in three or four color bands, the colors are placed and read in this order: A—body color, which stands for the first significant figure; B—end color, which stands for the second significant figure; C—dot color, which stands for the multiplier; and D—tolerance color (at the other end), which stands for the percentage of tolerance. For example, as shown in Fig. 3-7, a 100-ohm resistor with a tolerance of 10% would have a brown body (one), a black end color (zero), a brown dot (add one zero), and a silver tolerance end (10%). It is not possible to mistake the ends, because gold or silver can never stand for a significant figure. If there is no tolerance color (no gold or silver end), the tolerance is $\pm 20\%$.

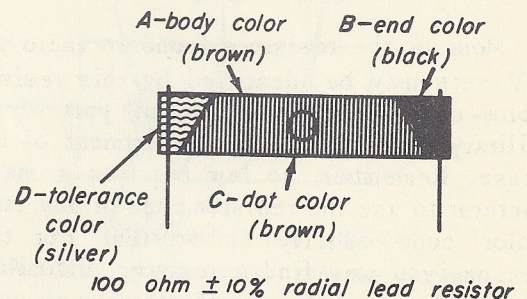
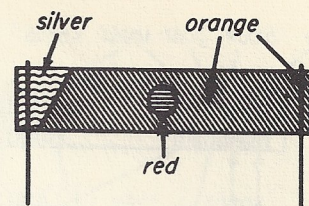


Fig. 3-7

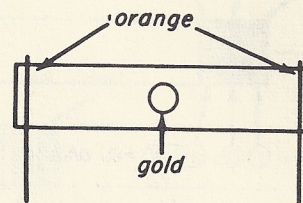
Sometimes the multiplier is represented by a band in the middle, instead of by a dot. The same method of reading colors that is used for axial lead resistors, Fig. 3-4, is used for radial-lead resistors. Instead of Band A, read the body color; instead of Band B, read the end color; instead of Band C, read the middle dot or band; and instead of Band D, read the tolerance end.

There are some special cases that come up in reading the color code on radial-lead resistors. This is because the body of the resistor and one of the color-code markings on the body may be the same color. Some resistors have no end markings, others have no middle dot or band, and still others have no markings other than a body color. These resistors are properly color coded, even though they seem puzzling at first glance. Where there is no separate end color, the end color is taken to be the same as the body color. Where there is no separate middle dot or band color, it, too, is the same as the body color. For example, a resistor with an orange body, with one end the same color, the other end silver, and with a red middle dot, as in Fig. 3-8a, would be decoded 3 (orange), 3 (orange), add two zeros (red), and a tolerance of plus or minus 10%. Because gold or silver can never be a significant figure, we know that the end marked with silver must stand for the tolerance. On the other hand, a resistor with an orange body with a gold middle dot and no other markings, as in Fig. 3-8b, would be decoded 3 (orange), 3 (orange), and multiplied by 0.1 (gold). This would identify a resistor of 3.3 ohms with a tolerance of plus or minus 20%. In much the same way, a resistor that is completely red, as in Fig. 3-8c, would be decoded 2 (red), 2 (red), add two zeros (red), and stand for a resistor of 2,200 ohms plus or minus 20%.

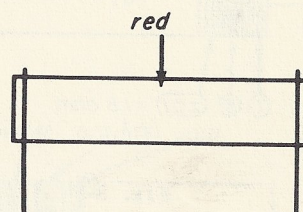
Most of the resistors found in radio and TV sets may be identified by this resistor color code, which has become part of the Military Standards of the Department of Defense. Remember, no law requires a manufacturer to use the resistor code or any other color code exactly as written. For that reason, you may find a resistor difficult to decode because the manufacturer took some liberties with the code. With a little thought,



3300-ohm $\pm 10\%$ resistor
(a)



3.3-ohm $\pm 20\%$ resistor
(b)



2200-ohm $\pm 20\%$ resistor
(c)

Fig. 3-8

you will probably be able to puzzle out the value even in these special cases.

The resistor code is the color code that you will probably use most often in your work. You will save yourself a lot of time and work much more efficiently if you will learn this code by heart. The test that you will find at the end of this lesson includes many questions based on the resistor code. When you have completed this lesson, take the test and see how much you really know about color codes.

3-4. CAPACITOR CODES

Mica Dielectric Capacitor Code. The next code that you should know about is the color code for mica dielectric capacitors. At this time, it is not necessary that you learn this code by heart; but you should learn how to use it. Actually there are and

there have been many forms of the mica capacitor code. Some of them are outdated and were used so seldom that it does not pay to learn them. For this reason, they are not included in this lesson. There are, however, four mica codes which you should know something about. They are: the old RMA (Radio Manufacturers Association) 3-dot, the old RMA 6-dot, the new RETMA (Radio Electronic Television Manufacturers Association), and the Military Standards codes.

Fortunately, these codes are basically the same and use the same color system as the resistor code. The easiest to learn is the old RMA 3-dot color code. While this code and the old RMA 6-dot code are almost outdated, there are so many capacitors that were marked by these codes that you should know how to identify them.

The Old RMA 3-Dot Code. Figure 3-9 shows three capacitors that are marked under the 3-dot code. In using this code, it is important to know in which order the color markings on the capacitors are to be read. In the 3-dot code, they are always read from left to right. The only difficulty might be in trying to find out which way to hold the capacitor while reading the code. Two of the capacitors shown have arrows. When the capacitor is held so that the arrows point from left to right, it is in the proper position for reading. If the arrow points from right to left, turn the capacitor half way around, so that the arrow points from left to right, before reading. In the third capacitor, there is no arrow. In this case, the capacitor is held so that the manufacturer's name is right side up so that it can be read. When the capacitor is in this position, the 3-dots are read from left to right as on the other capacitors. The unit of capacity is the farad. However, the capacity of mica dielectric capacitors is given in micromicrofarads (sometimes abbreviated mmf, sometimes $\mu\mu f$), whenever the color code is used.

The Old RMA 3-dot color code is applied in this manner: The first dot (the one on the left) stands for the first significant figure, the middle dot stands for the second significant figure, and the third dot (the one on the right) is the multiplier and stands for the

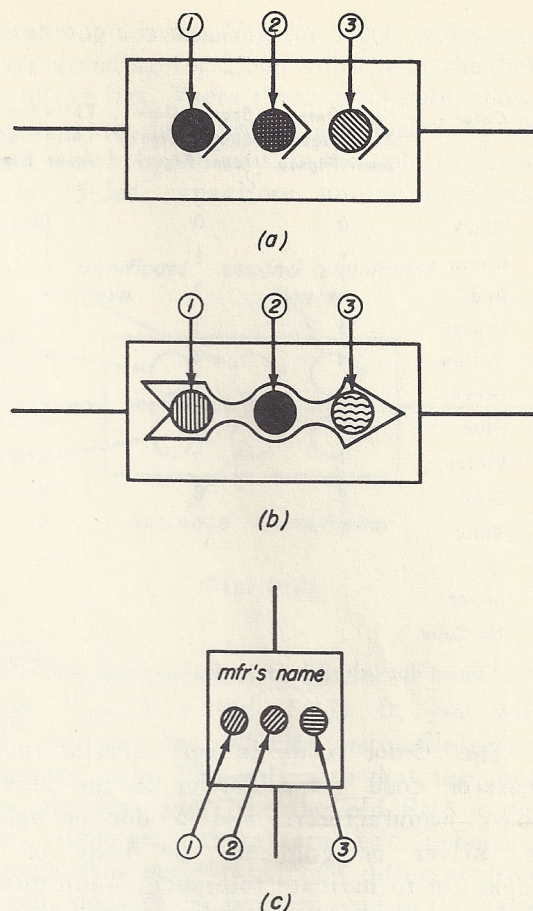


Fig. 3-9

number of zeros added to the first two digits. For example, a capacitor that has red for the first dot, green for the second dot, and brown for the third dot, as in Fig. 3-10, would be decoded as follows: 2 (red), 5 (green), add zero (brown). This stands for a capacitor of $250 \mu\mu f$. Figure 3-11 and Table C show the code applied to the old RMA 3-dot and 6-dot coded capacitors. The first two columns and the multiplier column apply to the 3-dot code. All six columns apply to the 6-dot code.

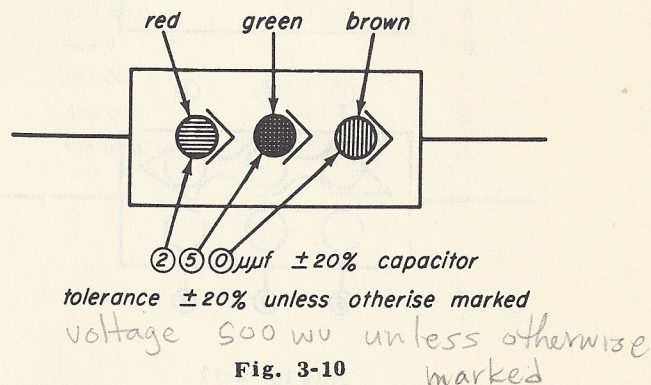


Fig. 3-10

TABLE C - OLD RMA MICA-DIELECTRIC CAPACITOR CODE

Color	First Dot— First Signif- icant Figure	Second Dot— Second Signif- icant Figure	Third Dot— Third Signif- icant Figure	¹ Fourth Dot - Multiplier		Fifth Dot— Tolerance	Sixth Dot— Voltage Rating
				Multiplier	Number of Zeros Added		
Black	0	0	0	x1	Add no 0		
Brown	1	1	1	x10	Add 0	+1%	100 wv
Red	2	2	2	x100	Add 00	+2%	200 wv
Orange	3	3	3	x1,000	Add 000	+3%	300 wv
Yellow	4	4	4	x10,000	Add 0000	+4%	400 wv
Green	5	5	5			+5%	500 wv
Blue	6	6	6			+6%	600 wv
Violet	7	7	7			+7%	700 wv
Gray	8	8	8			+8%	800 wv
White	9	9	9			+9%	900 wv
Gold				x0.1		+5%	1000 wv
Silver				x0.01		+10%	2000 wv
No Color						+20%	500 wv

¹ Third dot in the 3-dot code.

20% if no color all 500 wv
5% gold
10% silver

The 3-dot code is very similar to the resistor code given earlier in the lesson. Some manufacturers add a dot or splash of silver or gold on the body of the capacitor to indicate tolerance. When this is done, gold stands for plus or minus 5%, and silver for plus or minus 10%, as in the case of the resistor color code. When only the 3 dots are given, the tolerance is plus or minus 20%.

The Old RMA 6-Dot Code. Where the old RMA 6-dot code, shown in Fig. 3-12, is used, the manufacturer marks the capa-

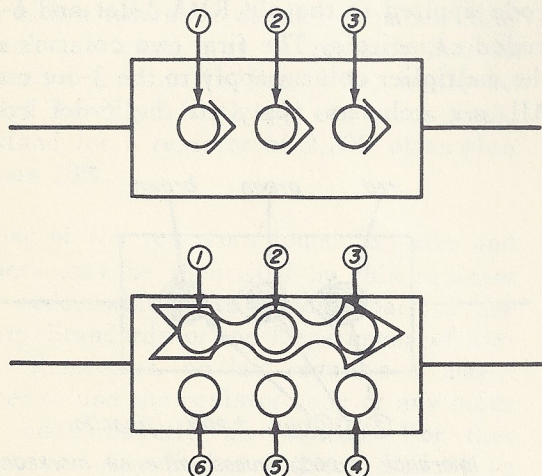


Fig. 3-11

citor with an arrow or his name to show how to hold the capacitor when reading the code. When there are 6-dots and the capacitor is held in the proper manner, the code is read from left to right on the *top* row of dots and from right to left on the *bottom* row of dots. (We say that it is read *clockwise* because we read in the direction that clock hands move.) The first three dots (on the top line) stand for the first three significant figures. The first dot stands for the first significant figure, the second dot stands for the second significant figure, the third dot stands for the third significant figure, the fourth dot (the one in the lower right-hand corner) stands for the multiplier (the number of zeros to be added), the fifth dot stands for the tolerance, and the sixth dot (in the lower left-hand corner) stands for the voltage rating. This last rating shows how much of

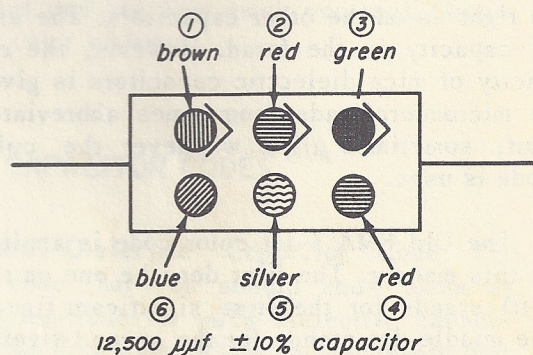


Fig. 3-12

what can be called electrical pressure may be connected across the capacitor. It is sometimes called the *working voltage*, abbreviated *wv*. In your later studies of capacitors, you will find that this is an important factor.

Let's take an example and see how this code works. A capacitor of 12,500 μmf , with a tolerance of plus or minus 10%, and a voltage rating of 600 volts, would be coded as follows: the first significant figure (1) would be represented by brown, the second significant figure (2) would be represented by red, the third significant figure (5) would be represented by green, the two zeros would be represented by red in the fourth dot, the tolerance plus or minus 10% by silver in the fifth dot, and the voltage rating by blue in the sixth dot.

While the old RMA mica capacitor codes are very much like the resistor color code, there are some differences that you must know about. Look carefully at the fifth (tolerance) column of Table C and you will see that each color, with the exception of black, represents a tolerance. Either gold or green could be used to stand for a tolerance of plus or minus 5%. Under this old code, it was possible to show a tolerance of plus or minus 1%. In the sixth column (voltage rating), you will find that every color except black represents a voltage rating, with brown standing for 100 volts, at the top of the list,

and with gold standing for 1,000 volts, and silver standing for 2,000 volts near the bottom of the list. Where there is no color shown in the sixth dot, the voltage rating is 500 volts, which, by the way, is the voltage rating of all 3-dot capacitors unless otherwise marked.

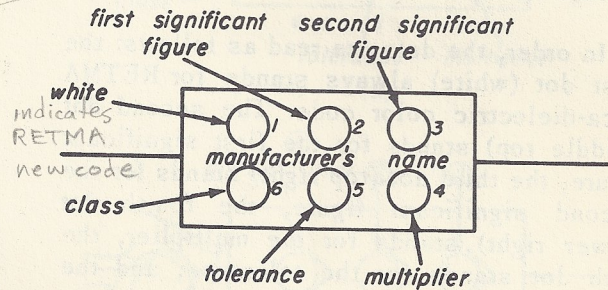


Fig. 3-13

RETMA Mica-Dielectric Code. If you examine Fig. 3-13 and Table D, you will find the present RETMA mica-dielectric capacitor code. You will note that the code uses six dots just like the old RMA 6-dot code. However, there are two important changes that make this code different from the old code. The 6 dots are read in the same order as the old code, but the first dot no longer stands for a significant figure. Instead, it is always white, which is to let you know that the capacitor uses the RETMA code. This is done because the Armed Forces use a somewhat different code, which might be confused with this one. The other change

TABLE D - RETMA MICA-DIELECTRIC CAPACITOR CODE
FIRST DOT WHITE ON ALL

Color	Second Dot - First Signif- icant Figure	Third Dot - Second Signif- icant Figure	Fourth Dot - Multiplier		Fifth Dot - Tolerance	6th Dot - Class
			Multiplier	Number of Zeros Added		
Black	0	0	x1	Add no 0	±20%	A
Brown	1	1	x10	Add 0		B
Red	2	2	x100	Add 00	±2%	C
Orange	3	3	x1,000	Add 000	±3%	D
Yellow	4	4	x10,000	Add 0000		E
Green	5	5			±5%	
Blue	6	6				
Violet	7	7				
Gray	8	8				
White	9	9				I
Gold			x0.1			J
Silver			x0.01		±10%	

affects the sixth dot, which no longer stands for a voltage rating but stands for a new class rating. The working voltage rating of mica capacitors is not given by the RETMA or military codes. For radio work, it may be assumed that most mica capacitors have a voltage rating of at least 500 volts d.c.

In order, the dots are read as follows: the first dot (white) always stands for RETMA mica-dielectric color code. The second dot (middle top) stands for the first significant figure, the third dot (top right) stands for the second significant figure, the fourth dot (lower right) stands for the multiplier, the fifth dot stands for the tolerance, and the sixth dot stands for the class of capacitor. For example, a capacitor coded as follows: white, red, green, brown, green, and brown, would be decoded as follows: RETMA coded mica-electric capacitor (white), 2 (red), 5 (green), add one zero (brown), plus or minus 5% tolerance (green), and Class B (brown). This would show a 250- μf , plus or minus 5%, Class B mica-dielectric capacitor. If you examine the tolerance column of Table D, you will find tolerances of 2, 3, 5, 10, and 20%. Note that a tolerance of plus or minus 5% is represented by green instead of gold, and that plus or minus 20% is represented by black instead of by no color at all.

The sixth dot, which refers to the manufacturer's classification, includes many factors that do not enter into our work.

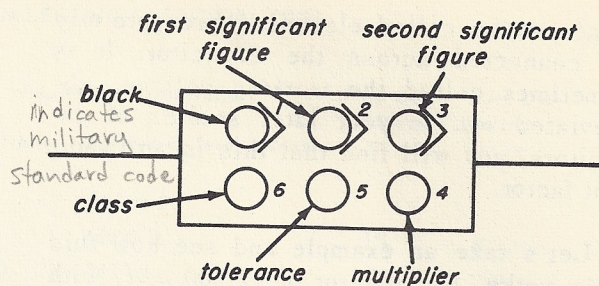


Fig. 3-14

Military Standard Mica-Dielectric Capacitor Color Code. Look at Fig. 3-14 and Table E. The Military Standard Color Code for mica capacitors looks very much like the code just discussed. It has, however, some differences which make it important for us to examine it separately. It is read in the same way that the RETMA mica code is read. However, the first dot (in the upper left-hand corner) is always black instead of white to indicate the Military Standard Color Code. A black dot in this position never stands for zero in any code. As in the RETMA color code, the second dot stands for the first significant figure, the third dot stands for the second significant figure, the fourth dot stands for the multiplier, the fifth dot stands for the tolerance, and the sixth dot stands for the class. It differs from the RETMA code in that there is no tolerance for plus or minus 3% and that plus or minus 5% is gold instead of green. It differs in the class column in that there are no Classes A, I or J,

TABLE E - MILITARY STANDARD MICA-DIELECTRIC CAPACITOR CODE
FIRST DOT ALWAYS BLACK

Color	Second Dot— First Signif- icant Figure	Third Dot— Second Signif- icant Figure	Fourth Dot — Multiplier Multiplier	Number of Zeros Added	Fifth Dot— Tolerance	6th Dot— Class
Black	0	0	x1	Add no 0	±20%	
Brown	1	1	x10	Add 0		B
Red	2	2	x100	Add 00	±2%	C
Orange	3	3	x1,000	Add 000		D
Yellow	4	4				E
Green	5	5				F
Blue	6	6				
Violet	7	7				
Gray	8	8				W
White	9	9				X
Gold			x0.1		±5%	
Silver			x0.01		±10%	

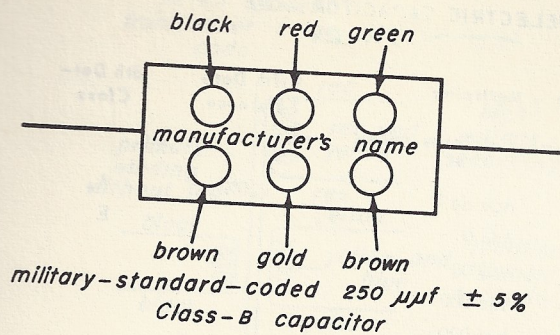
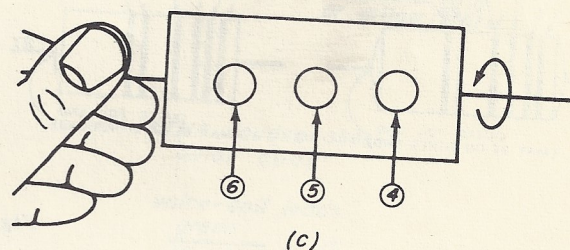
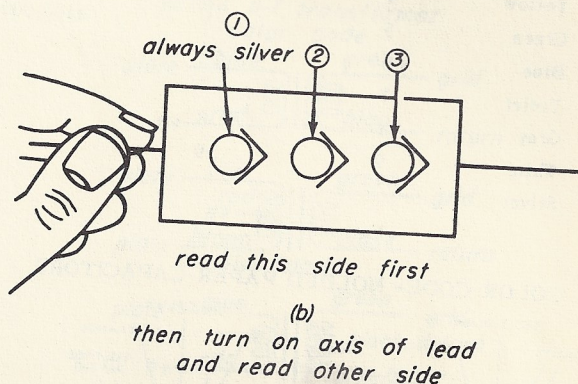
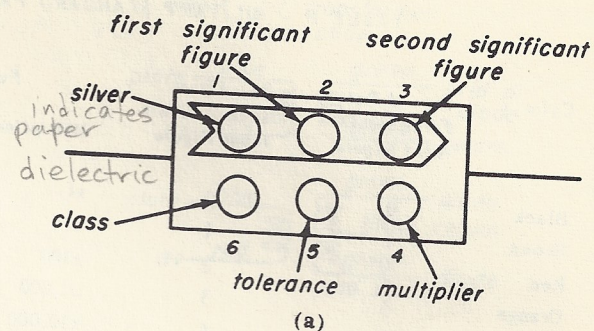


Fig. 3-15

and it has Classes F, W, and X, which the RETMA does not. In this code, a 250- μf Class B capacitor with a tolerance of plus or minus 5% would be coded as follows: black for the first dot, followed by red, green, brown, gold and brown, as shown in Fig. 3-15.



(b) and (c) military-standard-coded paper-dielectric capacitor with three dots on each side

Fig. 3-16

Military Standard Paper-Dielectric Capacitors. Some capacitors that are made for the Armed Forces have paper dielectric and are enclosed in bakelite cases. They look very much like mica-dielectric capacitors, as Fig. 3-16 shows. These capacitors are coded with 6 dots, as shown in Fig. 3-16 just as are the mica-dielectric capacitors. In some cases, however, these capacitors have 3 dots showing on one side and the remaining 3 dots on the other side of the capacitor, as shown in the illustration. In this case, an arrow, or some similar device, as in Fig. 3-16a, is used to show which side is read first and the order in which the dots are to be read. The other 3 dots are read just as the second row of dots in the other 6-dot codes, after rotating the capacitor about on the axis of its leads, as in Fig. 3-16b. In other words, hold the capacitor between thumb and forefinger with the arrows pointing from left to right. The first dot will always be silver to show that it is a paper-dielectric capacitor. The second dot is the first significant figure and the third dot is the second significant figure. Now, still holding the capacitor between your thumb and forefinger, turn it half way around as shown in Fig. 3-16c and read the remaining 3 dots from right to left. The fourth dot, which is on the right, is the multiplier, the fifth dot is the tolerance, and the dot on the left is the class.

If you examine this code as it is shown in Table F, you will find there are three tolerances shown. Plus or minus 10% is silver, plus or minus 20% is black, and plus or minus 30% is orange. There are no other tolerances. There are two Classes: Class A (black) and Class E (brown). In replacing such a capacitor, it is important that one of the same class be used.

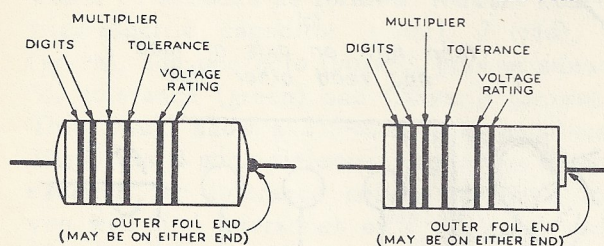
As in the case with the resistor code, not all manufacturers use the capacitor codes exactly as given in this lesson. However, well over 90% of the capacitors that are color coded use these codes as is. If you find one that differs from these codes, you might write directly to the manufacturer for information about his methods of coding.

TABLE F - MILITARY STANDARD PAPER-DIELECTRIC CAPACITOR CODE

FIRST DOT ALWAYS ~~BLACK~~ Silver

Color	Second Dot- First Signif- icant Figure	Third Dot- Second Signif- icant Figure	Fourth Dot - Multiplier Multiplier	Number of Zeros Added	Fifth Dot- Tolerance	6th Dot- Class
Black	0	0	x1	Add no 0	±20%	A
Brown	1	1	x10	Add 0		E
Red	2	2	x100	Add 00		
Orange	3	3	x1,000	Add 000	±30%	
Yellow	4	4	x10,000	Add 0000		
Green	5	5	x100,000	Add 00000		
Blue	6	6				
Violet	7	7				
Gray	8	8				
White	9	9				
Silver					±10%	

COLOR CODE - MOLDED PAPER CAPACITORS



The Voltage Rating is given in hundreds of volts. Only one band is employed for ratings under 1,000 volts. Two bands are employed for ratings over 1,000 volts. Use digit column to read voltage rating.

TOLERANCE	
COLOR	TOLERANCE
BLACK BAND OR NONE	±20%
WHITE OR SILVER	±10%
YELLOW OR GOLD	±5%

Fig. 3-17

Molded Tubular Paper Capacitor Code.

Molded tubular paper capacitors are color coded as shown in Fig. 3-17. The colors have the same values as before, except when used in the tolerance position, as shown in the chart in this figure.

3-5. RETMA WIRING COLOR CODE

While no circuit wiring code is in general use among manufactures of home receivers, some manufacturers use the RETMA wiring color code. Manufacturers of commercial communication equipment and all military communication equipment are generally required to use this wiring code. Probably many years will pass before the radio industry adopts it for all radio and electronic equipment. This code is included in this lesson so that you may identify the circuits in receivers that use it. Table G shows the complete wiring code.

TABLE G - RETMA CHASSIS WIRING CODE

Color	Circuit Name
Black	Grounds, grounded elements, and returns
Brown	Heaters or filaments, off ground
Red	Power supply B+
Orange	Screen grid
Yellow	Cathodes
Green	Control grids
Blue	Plates
Violet	Not used
Gray	A-C Power lines
White	Above or below ground returns, AVC, etc.

When leads for antenna and ground connections are provided on the receiver, the antenna lead will be blue and the ground lead black.

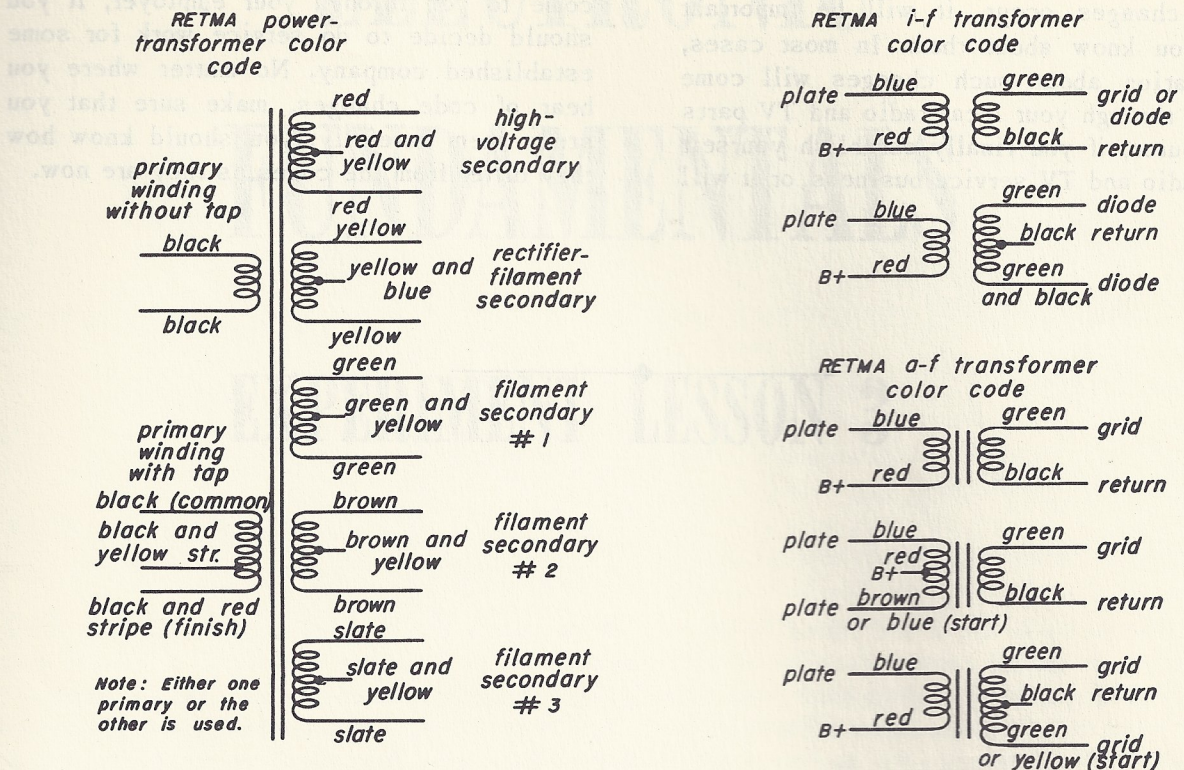


Fig. 3-18

3-6. RETMA TRANSFORMER CODE

Power transformers, intermediate frequency transformers, and audio-frequency transformers frequently come with color-coded leads so that their windings may be easily identified. While you have no immediate need for the transformer code, it is included in Fig. 3-18 for future use. Some of the terms used in identifying some of the windings may be strange to you now. However, by the time you have need for this information, you will know what the terms mean. At that time, it might be a good idea to learn this code.

3-7. RETMA LOUDSPEAKER CODE

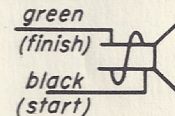
Some manufacturers use the RETMA loudspeaker code to identify voice-coil leads and field-coil leads. This code is shown for your future use in Fig. 3-19.

3-8. KEEP UP WITH CODE CHANGES

While not all of the codes included in this

RETMA loudspeaker color code

voice-coil leads



field-coil leads

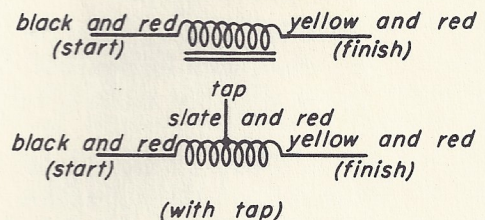


Fig. 3-19

lesson are in general use by radio manufacturers, they are well worth knowing about. This is particularly true of the resistor and mica dielectric capacitor codes. There are two or three codes that will be included in later lessons as needed.

An important factor to remember about codes is that they change from time to time.

When changes occur, it will be important that you know about them. In most cases, information about such changes will come to you through your local radio and TV parts distributor, if you finally establish yourself in a radio and TV service business, or it will

come to you through your employer, if you should decide to do service work for some established company. No matter where you hear of code changes, make sure that you study them carefully; you should know how they differ from the codes as they are now.



3-4 RETNA TRANSDUCER CODE

Power transformers, intermediate frequency transformers, and audio-frequency transformers are frequently coded with color-coded bands. As these transformers are coded, they are placed in the transformer code. The code is used in identifying some of the windings may be necessary to you now. However, by the time you have need for this information you will have the code. At that time it might be a good idea to learn this code.

3-5 RETNA LOUPEAKER CODE

Some manufacturers use the RETNA loudspeaker code to identify various loudspeakers and field-coil units. This code is shown in your issue in EIR 3-19.

3-6 KEEP UP WITH CODE CHANGES

While not all of the codes included in this